

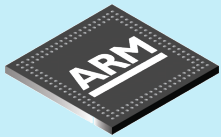
ARM® Cortex®-M7: Bringing High Performance to the Cortex-M Processor Series

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Senior Product Manager, ARM

ARM® Cortex® Processors across the Embedded Market

Cortex®-M processors

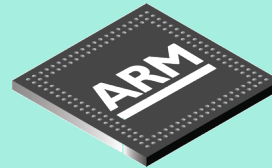
MCU + DSP



RTOS

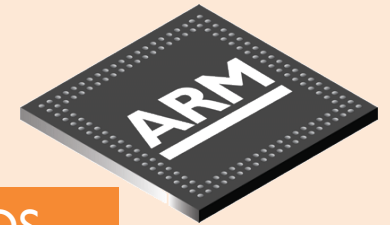
Smallest footprint / lowest power

Cortex®-R processors



Highest performance / real-time

Cortex®-A processors

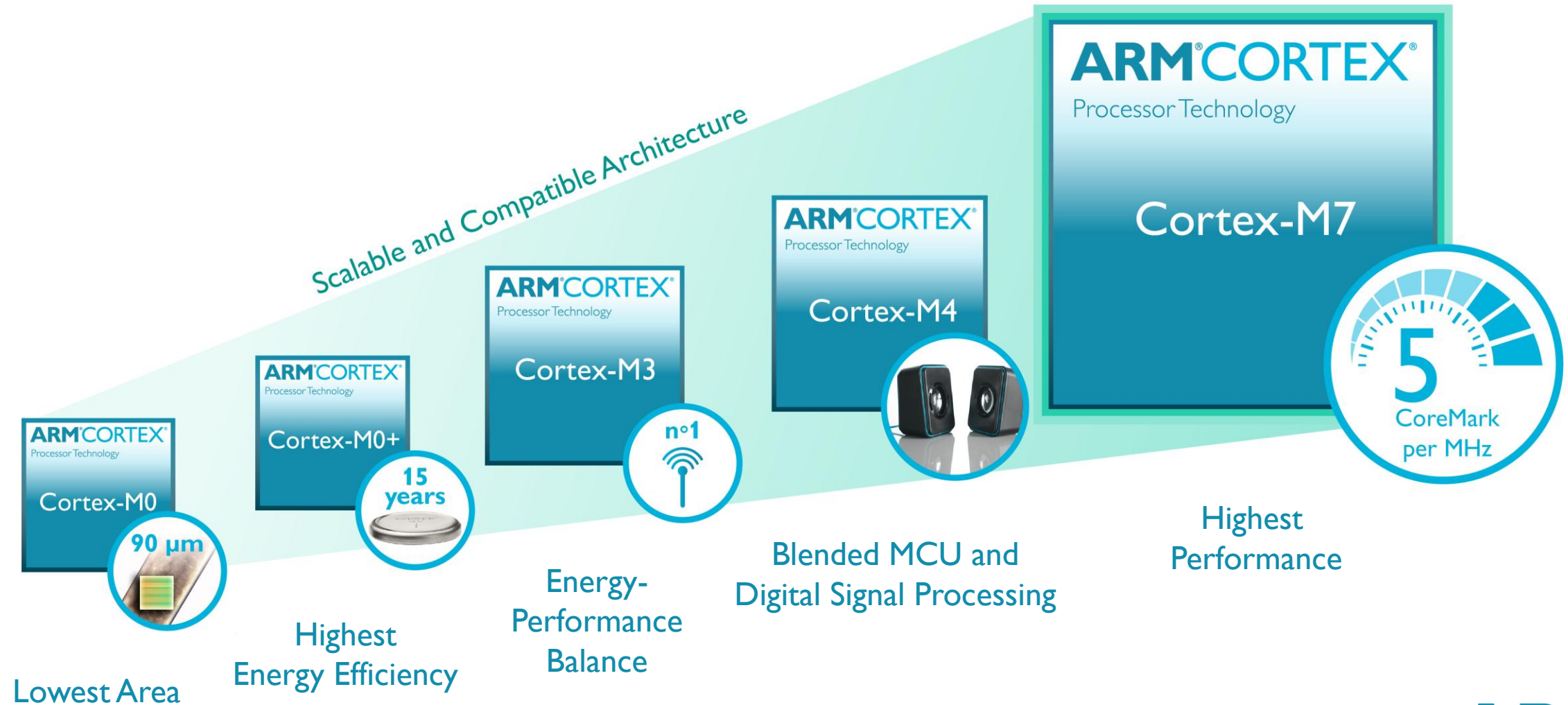


Rich OS

Highest performance

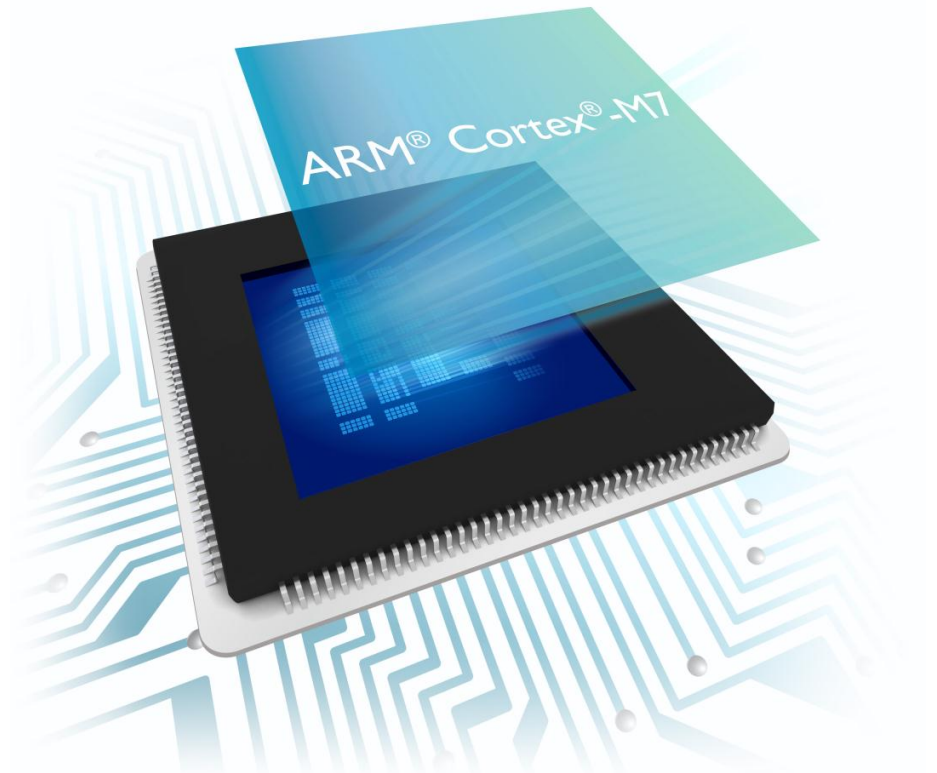


Taking the Cortex-M Series to the Next Level



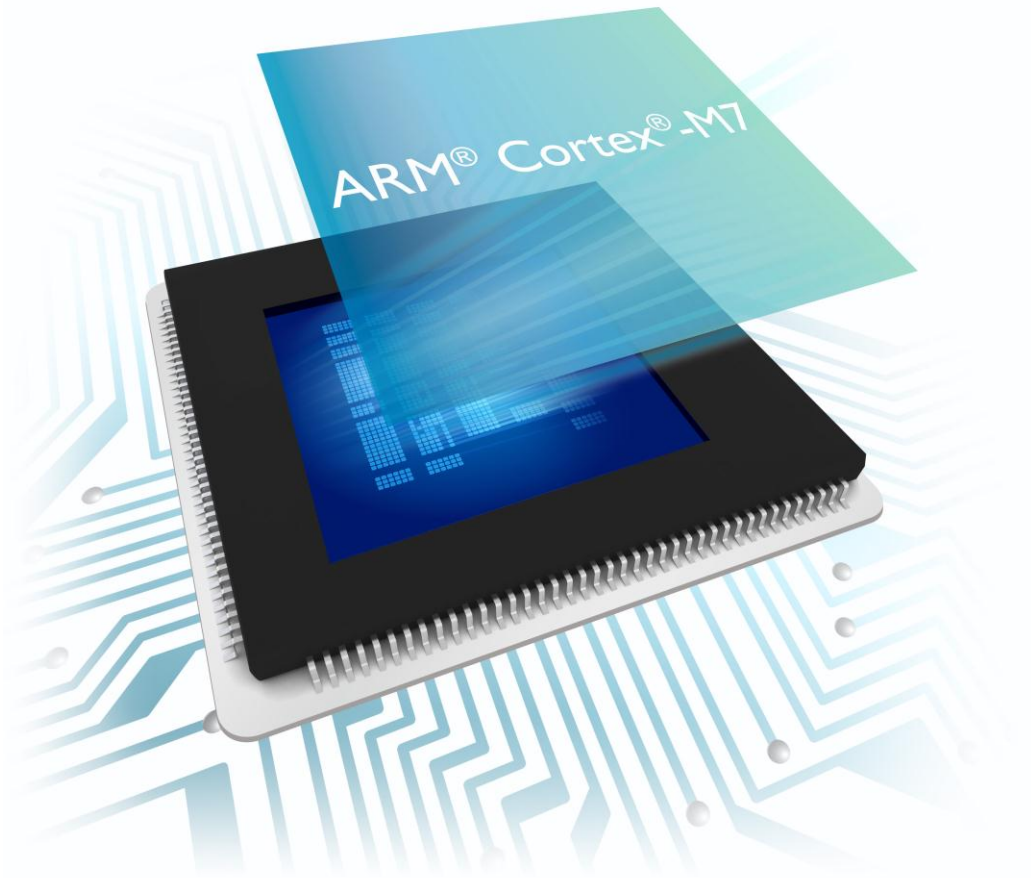
Cortex-M7 Overview

- Performance
 - Achieving 5 CoreMark/MHz – 2000 CoreMark* in 40LP
 - Typical 2x DSP performance of Cortex-M4
- Versatility
 - Highly flexible system and memory interfaces
 - Designed for functional safety implementations
- Scalability and compatibility
 - Enables simple migration from any Cortex-M processor
 - Widest third-party tools, RTOS, middleware support



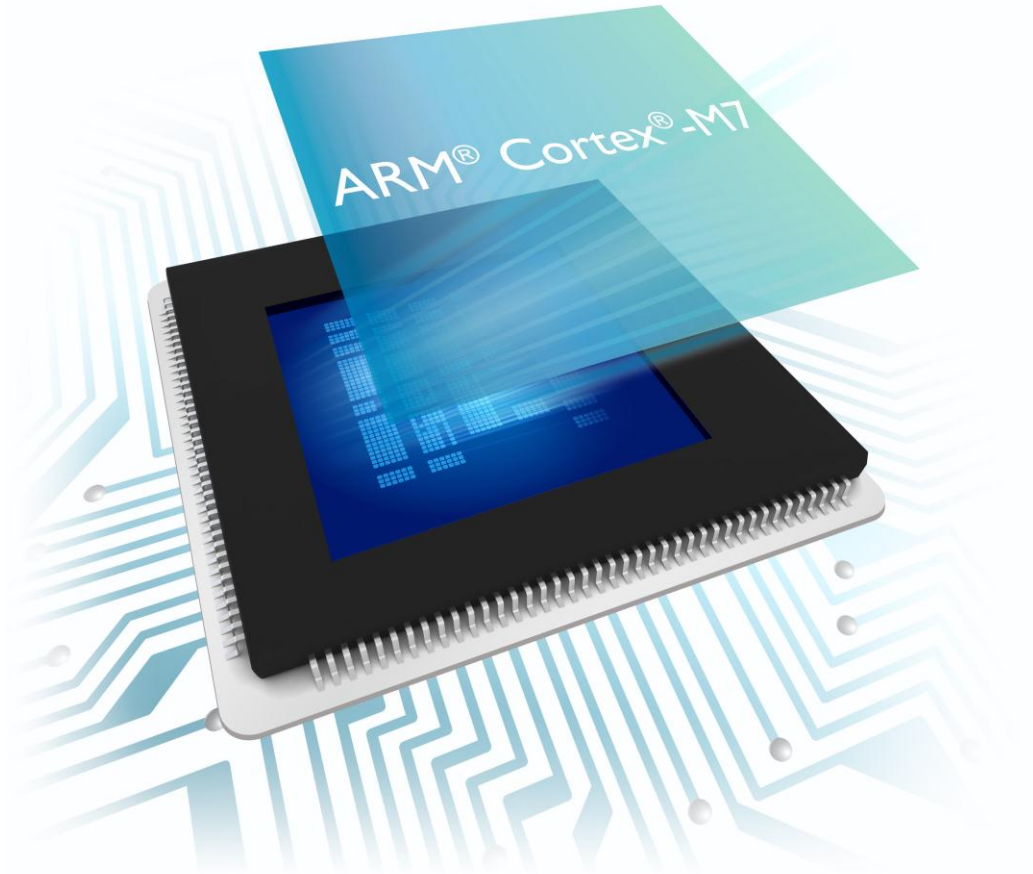
* CoreMark 1.0 : IAR Embedded Workbench v7.30.1 --endian=little --cpu=Cortex-M7 -e -Ohs --use_c++_inline --no_size_constraints / Code in TCM - Data in TCM

Cortex-M7 Key Features (I)



- **High-performance processor with DSP capabilities**
 - Six-stage superscalar pipeline
 - Powerful DSP instructions and SP/DP Floating Point
 - **Best-in-class core for high-end MCU or replace MCU+DSP with Cortex-M7**
- **Flexible, memory system**
 - Tightly-coupled memories for real-time determinism
 - 64-bit AXI AMBA4 memory interface with I-cache and D-cache for efficient access to external resources
 - **Build powerful MCU with more memories and powerful peripherals**

Cortex-M7 Key Features (2)



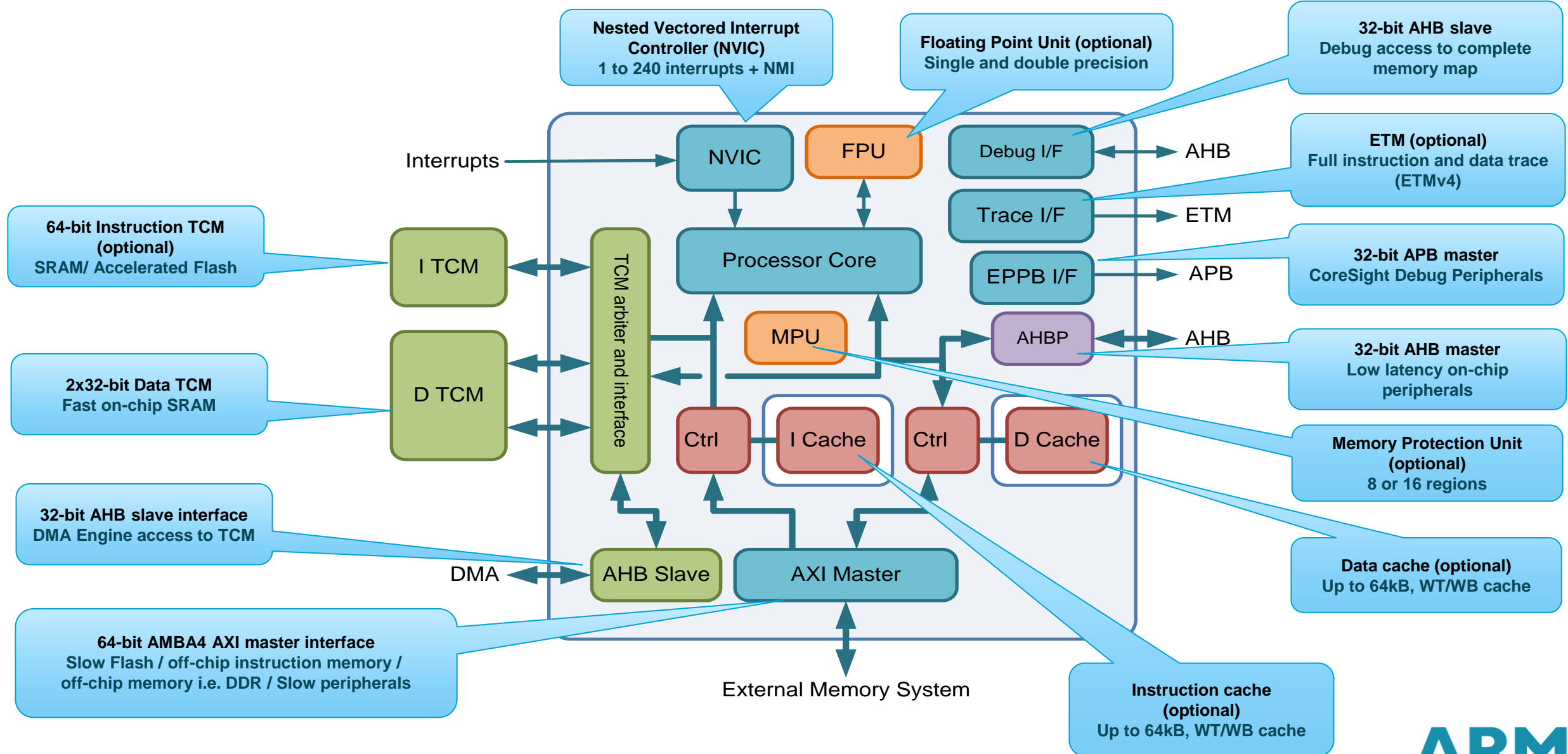
- **ARMv7-M architecture**

- 100% binary forwards compatibility from Cortex-M4
- Key Cortex-M family processor characteristics of ease-of-use and excellent interrupt latency
- **Reuse code and system design from existing products**

- **Safety features**

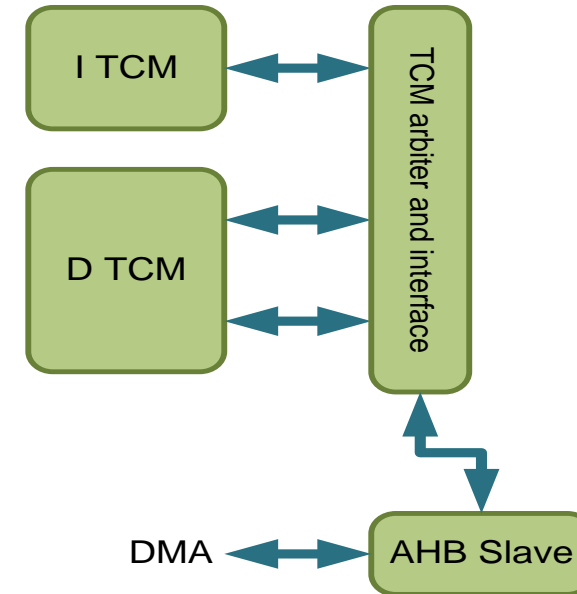
- Memory ECC (SEC-DED), MPU, MBIST, lock-step operation, full data trace, safety manual
- **Enables entry into safety-critical markets.**

Cortex-M7 Block Diagram



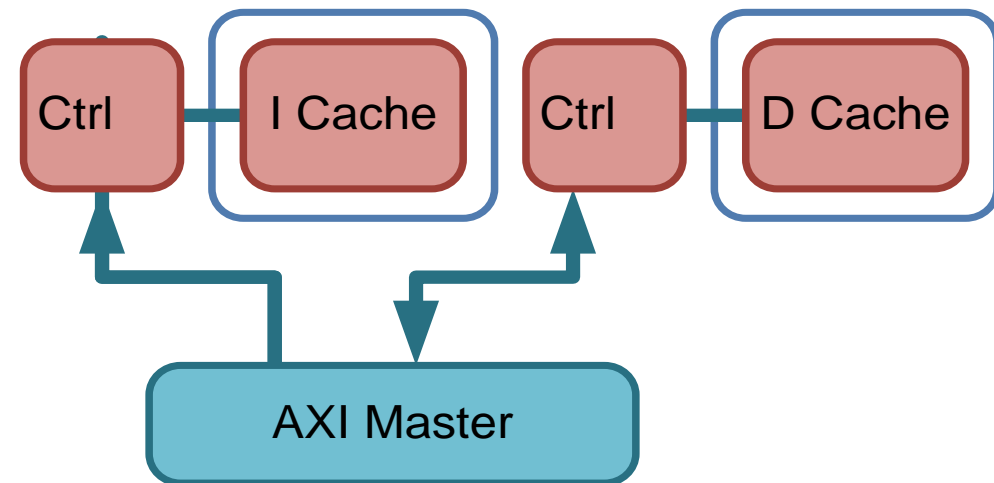
Tightly Coupled Memory (TCM)

- All TCMs:
 - Support wait-states
 - Can be used at boot-up time
 - Support up to 16MB of memory
- Provide deterministic performance
 - Dedicated store buffering
- Instruction TCM (ITCM)
 - 64-bit interface
- Data TCM (DTCM)
 - 2 X 32-bit interface: D0TCM and D1TCM, SSRAM protocol to enable direct integration with memories
 - Supports dual-issue of loads when bit [2] of address is different

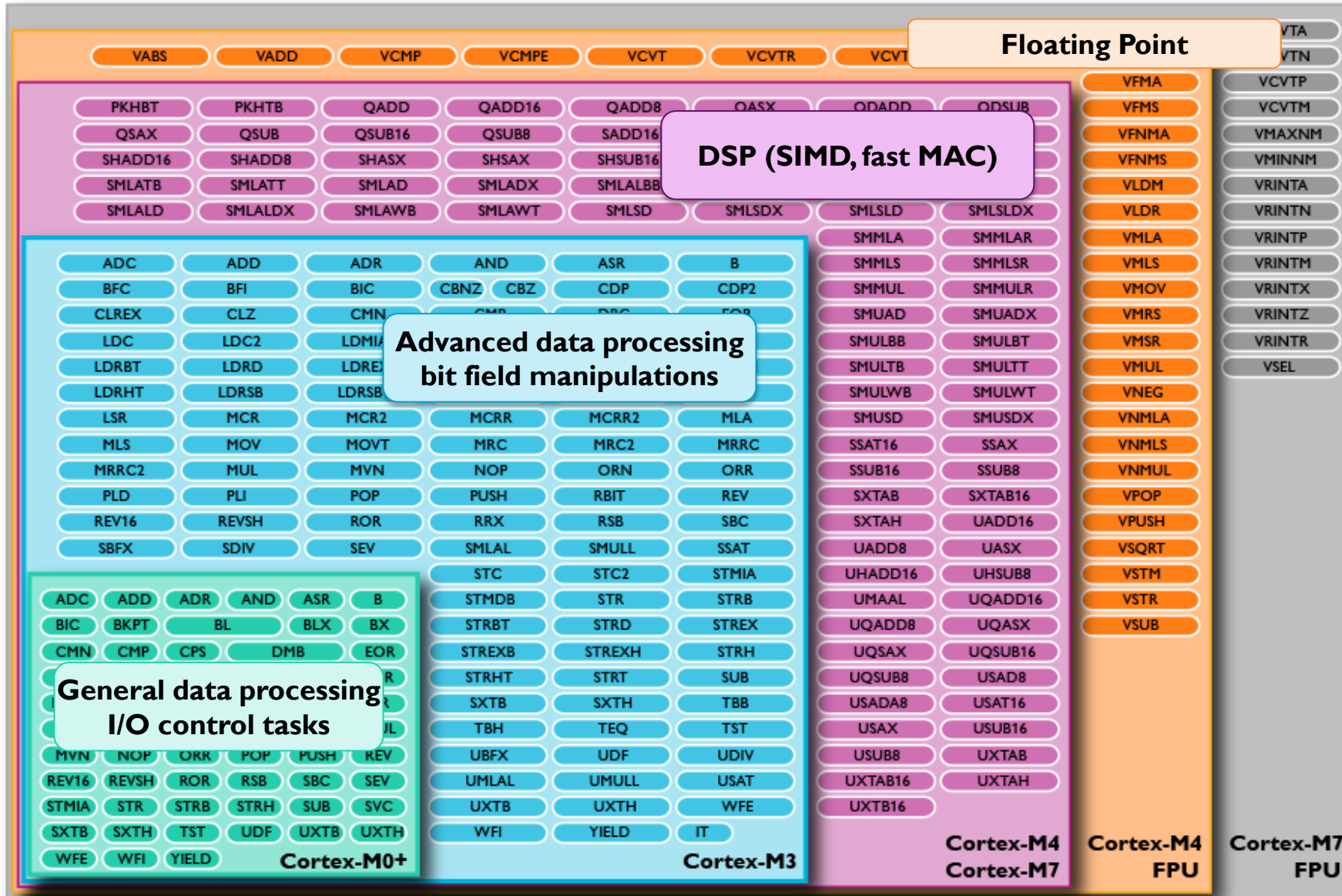


Caches - Overview

- Harvard arrangement for optimum performance
- I-cache 2-way associative, D-cache 4-way associative, pseudo-random replacement policy
- I and D both optional, configurable sizes (4kB – 64kB each)
- Extensions defined for the ARMv7-M system architecture
 - Addition of cache maintenance operations
- Full support for the following attributes
 - Write Through, no write allocate (WT)
 - Write-back, no write allocate (VWBRA)
 - Write-back, write allocate (VWBWA)



Powerful & Scalable Instruction Set



Cortex-M7 has the same powerful instruction set as Cortex-M4:

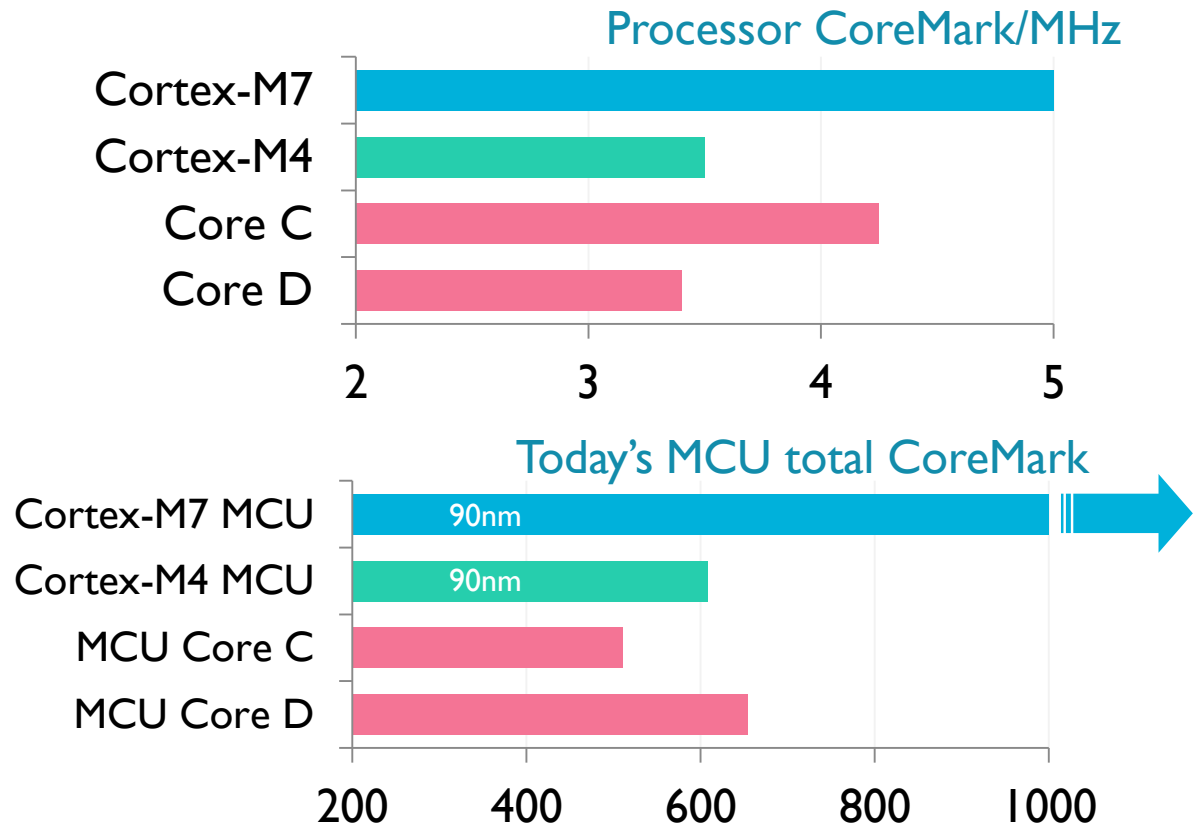
- Integer MAC instructions are all single-cycle
- SIMD instructions can work on 8-/16-bit quantities packed into a 32-bit word
- Arithmetic can be signed/unsigned, saturating/non-saturating
- A few new FP instructions for FPv5

ARM Cortex-M7: Built for Performance

- Fast compute for demanding embedded applications
 - Six-stage superscalar pipeline with branch prediction
 - Single and double precision floating point unit
- Flexible memory system
 - 64-bit AXI AMBA4 interconnect
 - I-cache and D-cache for efficient memory operation
- Ultra-fast responsiveness for control
 - 12 cycles interrupt latency
 - Tightly coupled memories for real-time determinism

**Highest core performance
combined with the efficiency of Cortex-M**

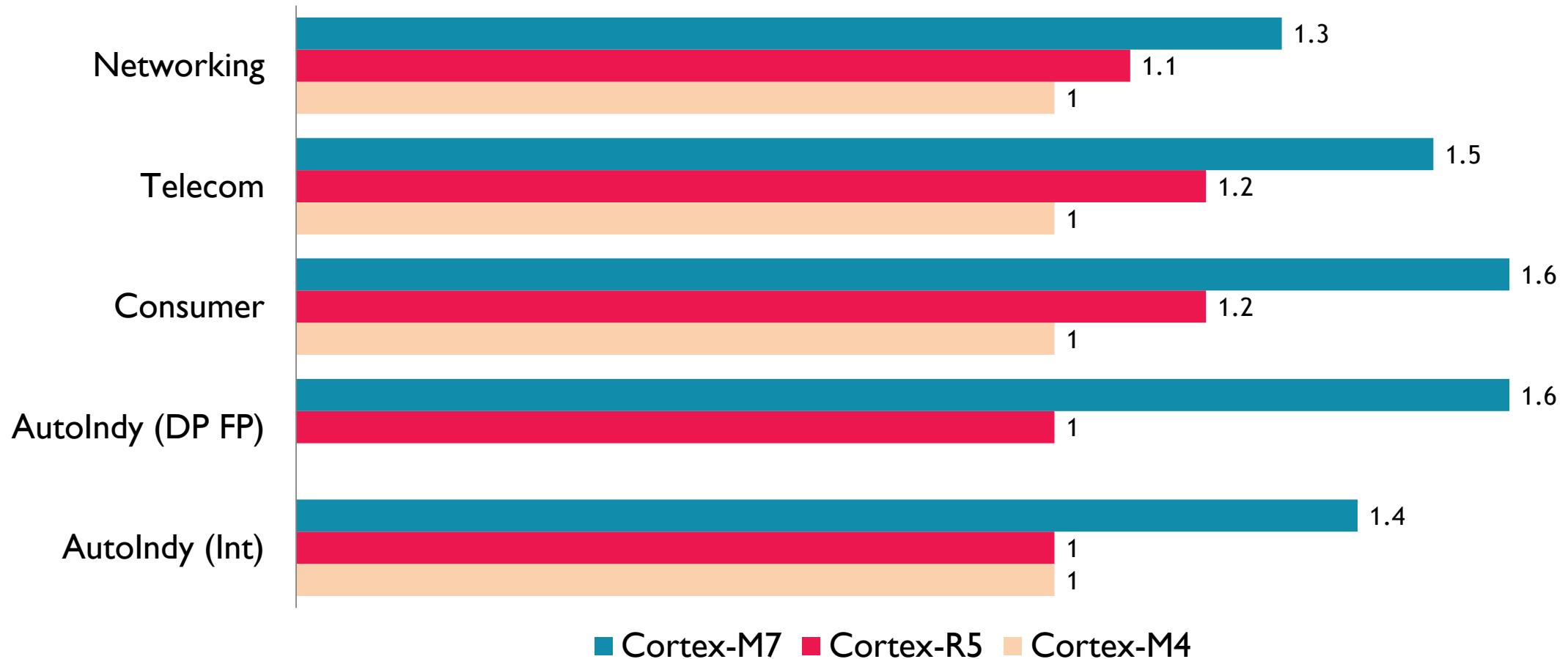
Higher = better



Source: CoreMark.org, ARM for Cortex-M7

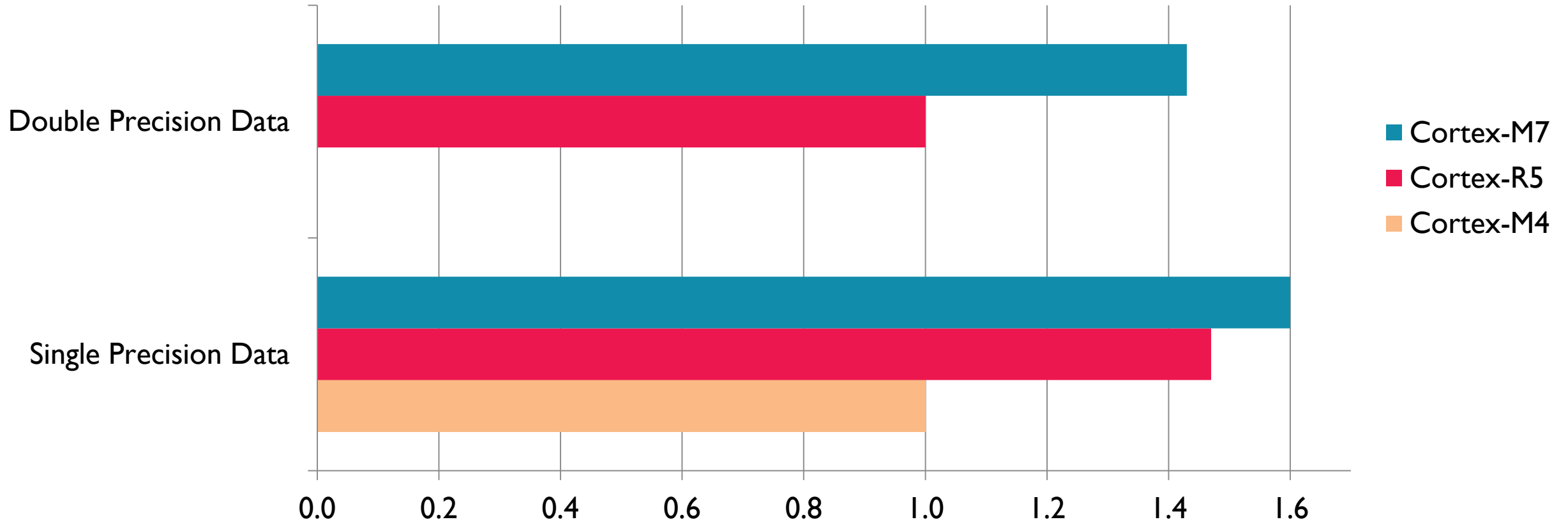
EEMBC IPC Comparison

- Results are geo-mean of EEMBC IPC relative to baseline (quantified as '1')
- Measured on comparable memory systems (in this case, WB caches on Cortex-M7)



FP Benchmarking Status

- Cortex-M7 floating point performance relative to Cortex-R5 and Cortex-M4 processors

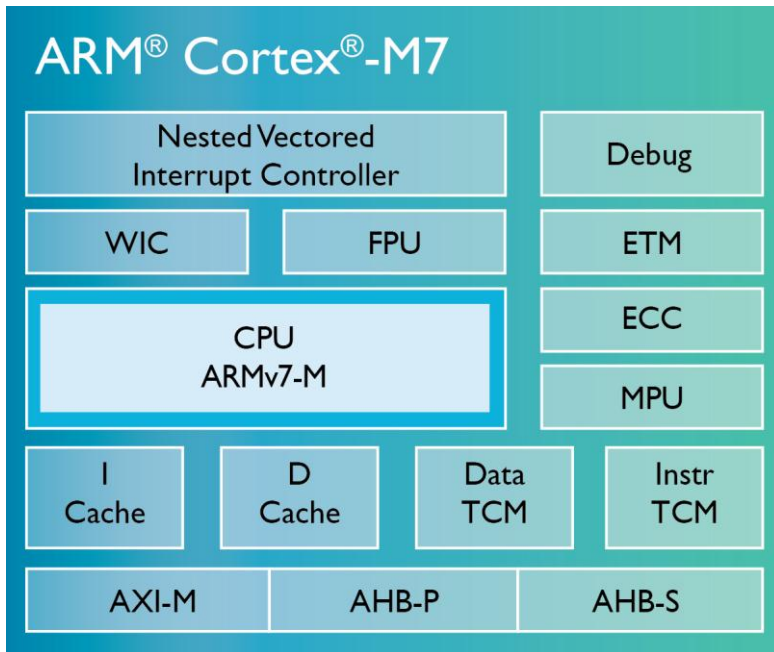


Assumes all processors running at the same clock frequency
Based on EEMBC FPMark benchmarks using 'small' data-sets
Performance relative to Cortex-R5 in the same system
Benchmarks compiled with ARM tool-chain (v5.04)

Cortex-M7: Competitive with Popular DSPs

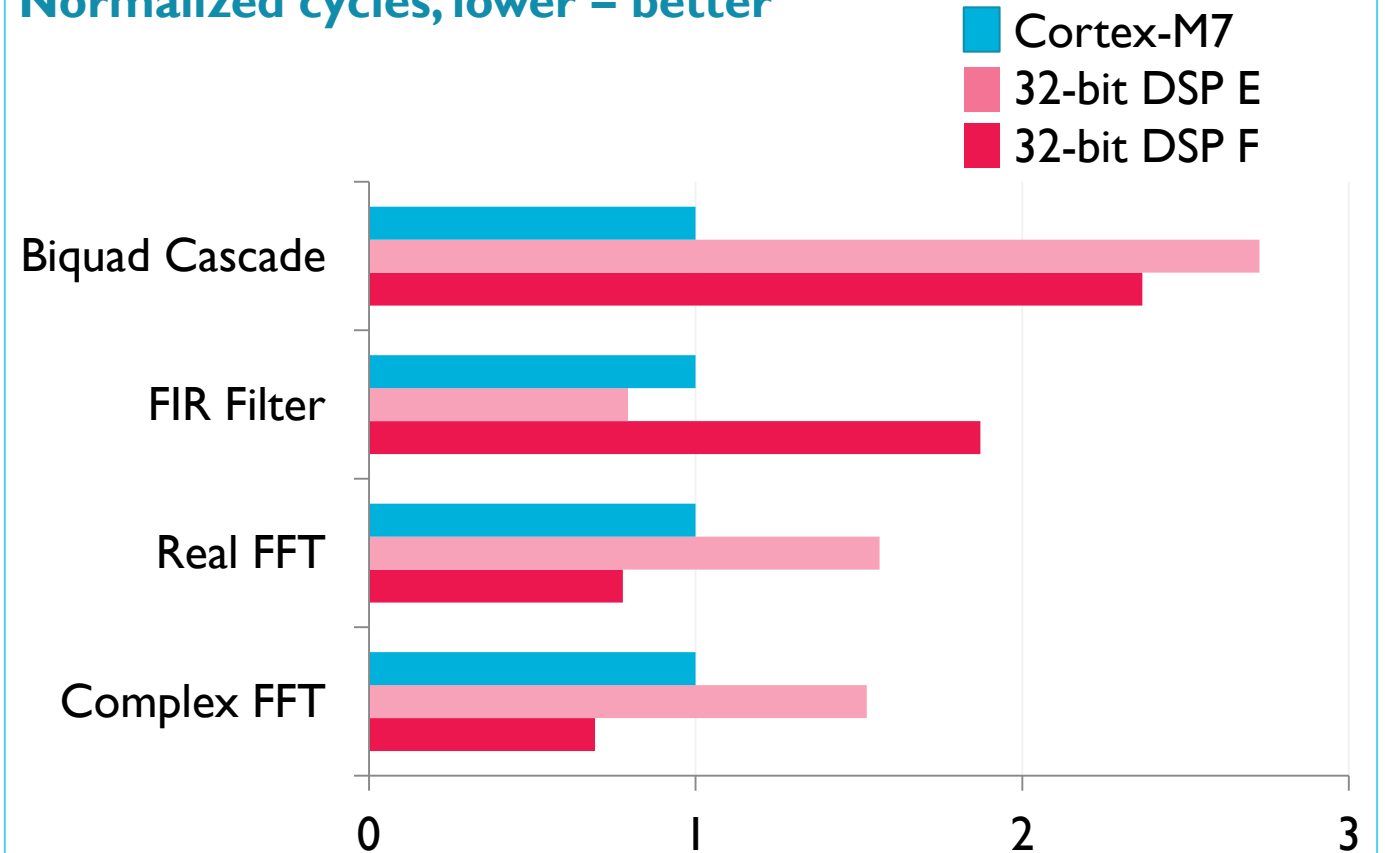
■ Essential DSP features

- Parallel execution of loads, stores and MAC
- SIMD support, single-cycle MAC
- Single and double precision floating point unit
- Minimal loop overhead (branch predictor/BTAC)
- Optimised DSP libraries

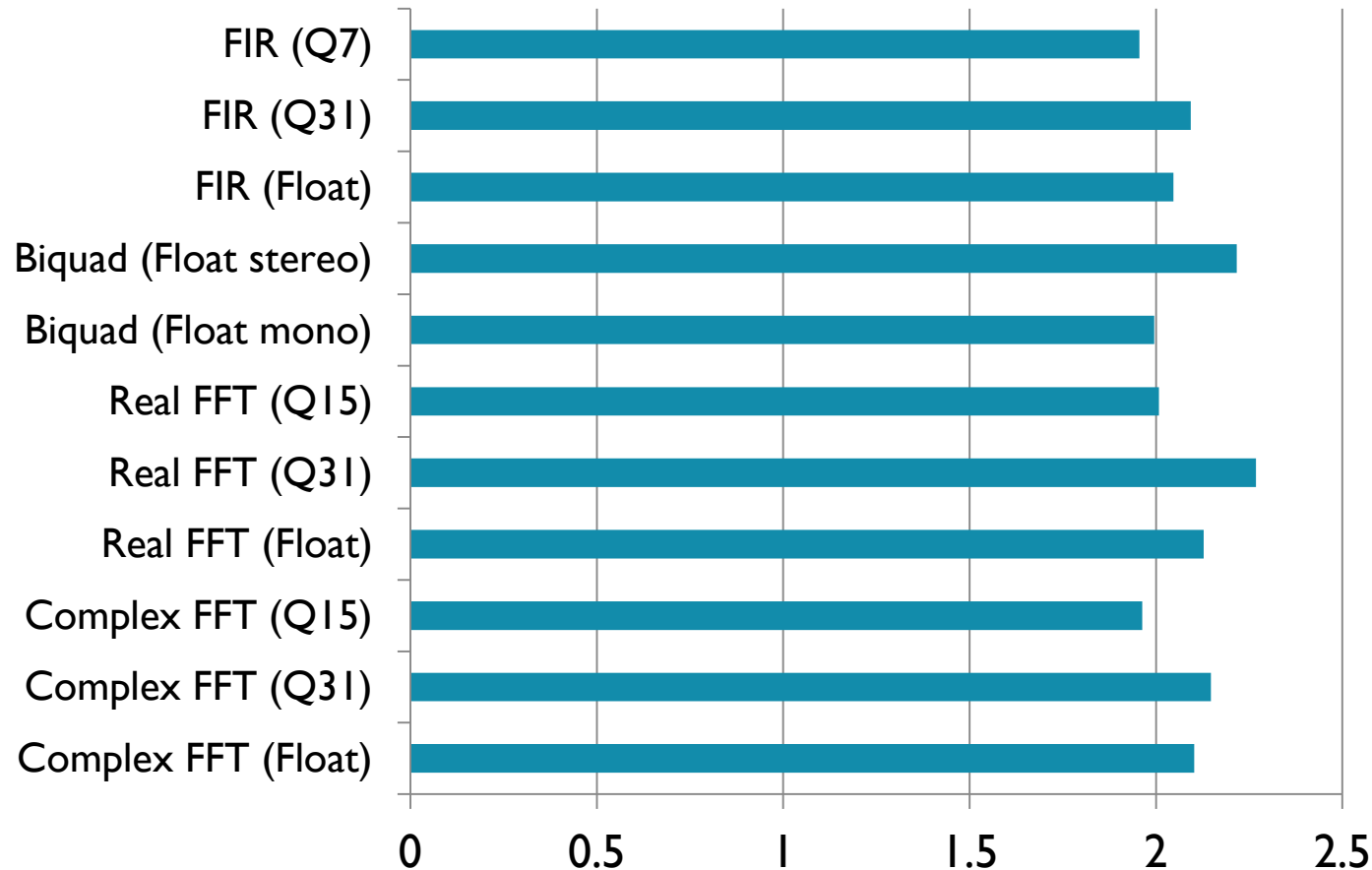


Consistently good performance across key DSP functions

Normalized cycles, lower = better



2x Performance Improvement over the Cortex-M4

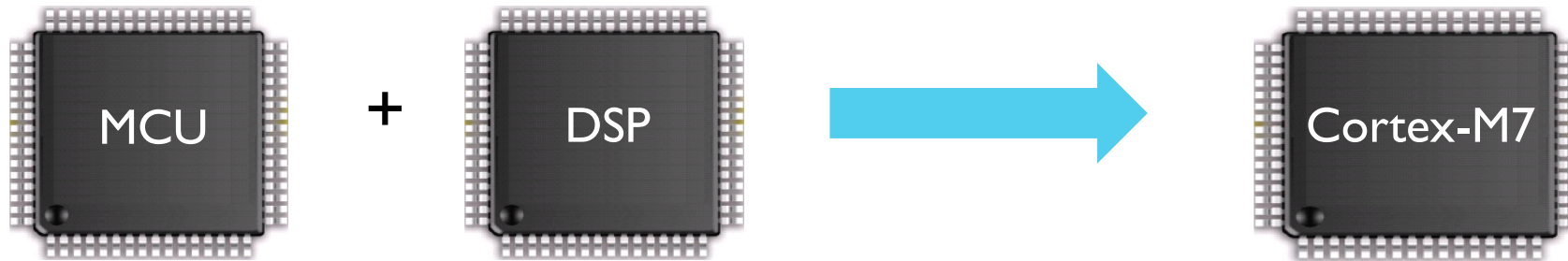


- Measurements using the CMSIS DSP Library
- Available free of charge from ARM
- Now optimized for the Cortex-M7



Note: combines architectural improvements with expected core clock increase.
The code was compiled using the ARM C Compiler (armcc) 5.04
Comparison was made on an FPGA on a Versatile Express motherboard

Cortex-M7 – Replacement for MCU+DSP



■ Trends:

- Convergence of MCU+DSP to DSC for cost reduction
- Increased processing demands
- Increasing consumer expectation of quality in portable devices

■ Example applications:

- Multi-channel audio / Dolby Audio
- Advanced Motor Control
- Factory Automation
- Automotive
- Image processing
- Power conversions

Cortex-M7 Advantages:

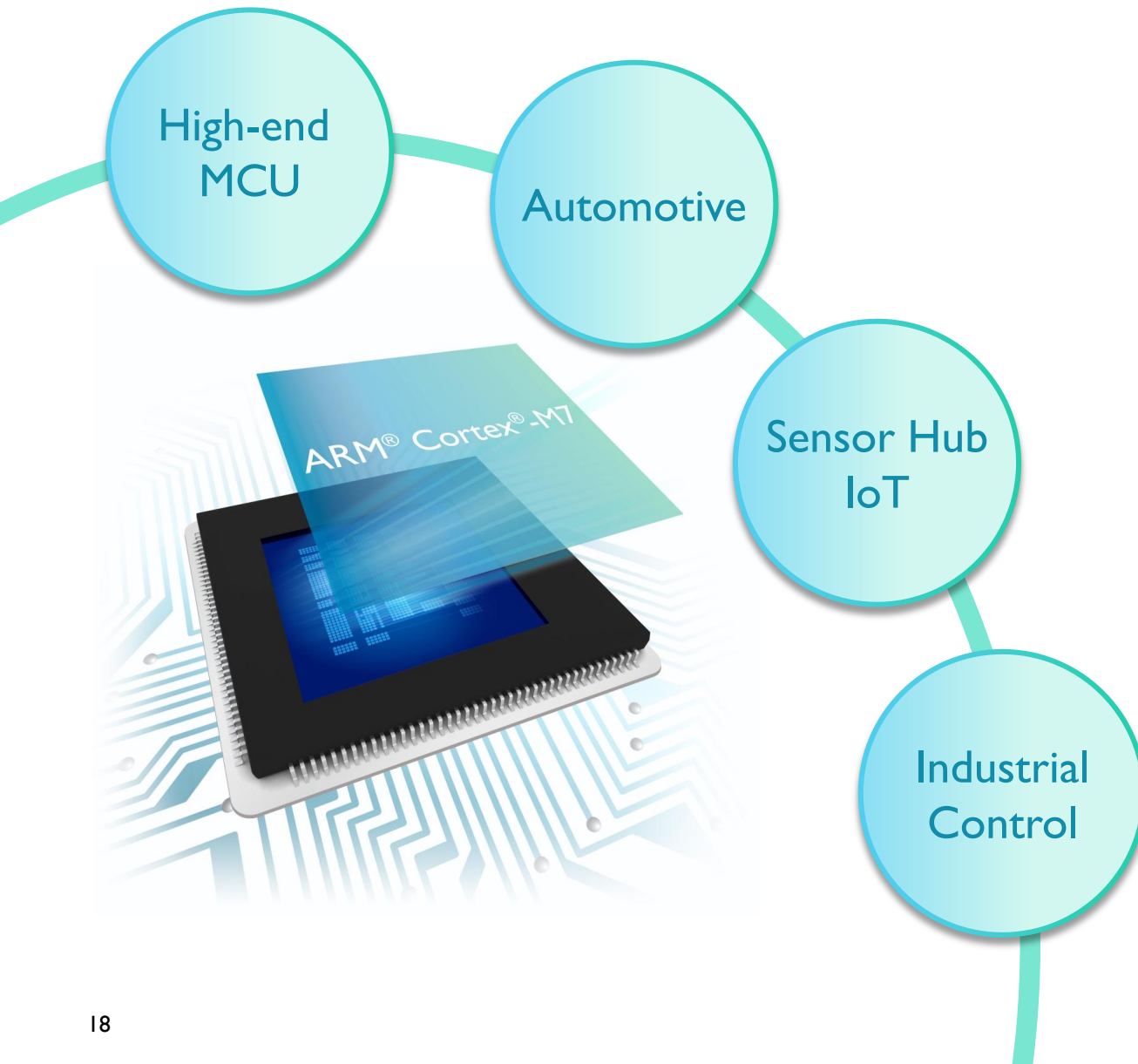
- High performance core with fast DSP
- Compatibility with existing Cortex-M4 designs
- Flexible memory system

Cortex-M7 Safety Features

- Cortex-M7 specific additions
 - Cache ECC
 - Dual core lock-step with delay
 - External TCM ECC interface
 - On-line MBIST interface
- ARMv7-M architecture based
 - Memory protection unit (MPU)
 - Exception logic
- These features will be included in the Cortex-M7 Safety Documentation Package:
 - Safety Manual
 - FMEA Report
 - Development Interface Report



Cortex-M7 Target Applications



- Powerful processor for advanced audio/visual sensor hub processing
- Power-efficient local processor for IoT devices such as an edge router
- Flexible and reliable processor for industrial and motor control

Enabling Smarter Systems Without the Complexity

2x



More performance

delivering enhanced functionality



More displays



More motors



Advanced touch sensing



Multiple connectivity options



Enhanced voice controls



Enabling More Capabilities for Feature-Rich Devices

2x



More performance

delivering improved flight management

Cortex-M7

400 MHz

Cortex-M4

168 MHz



Finer degree of control



Accurate speed measurement



Finer GPS accuracy



Secure telemetry radio

Source: 3DRobotics, PX4 autopilot ETH Zurich

Helping Drive Richer Audio Experiences

2x



More performance

delivering advanced sound processing

Cortex-M7

160 MHz

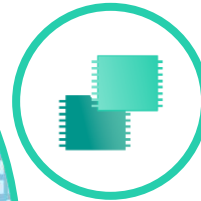


Cortex-M4

130 MHz



7.1 Multi-channel audio support



More speaker EQ processing



Capacity for decoders



More connectivity options

Cortex-M7 in Automotive

■ Trends and challenges:

- Safety certification mandated in more regions
- Convergence of functionality into fewer MCUs/ASSPs
- Increasing user requirements and expectations

■ Typical Applications

- Dashboard in medium-range cars
- Voice recognition
(for Multimedia control functions)
- Character recognition (eg Kanji)
- “Convenience” features
- Chassis, electric power steering, “steer-by-wire”
- Automotive audio



Cortex-M7 Advantages:

- High performance core with fast DSP
- Safety features built in and safety manual
- Determinism with high performance
- Full trace via ETM

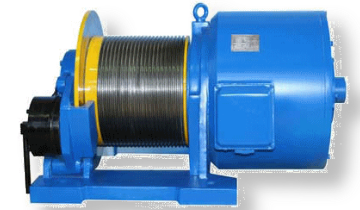
Cortex-M7 in Industrial Control

■ Trends and challenges

- High performance control functions
- Safety, reliability and conformance will become mandatory
- 80-90% of cost is software, Cortex-M offers scalability and protects software investment

■ Typical applications:

- Factory Automation
 - Inverters and servos
 - Programmable Logic Controllers
 - High-speed comms
- Intelligent motor control



Cortex-M7 Advantages:

- Increased DSP performance for control functions
- Safety features built-in
- In-order pipeline gives performance with predictability
- TCMs and low interrupt latency: Interrupt response within 100ns required
- Scalability from Cortex-M3 through Cortex-M7 up to Cortex-A53

Cortex-M7: Harnessing the Cortex-M Ecosystem



“ With support for the new Cortex-M7 processor, we are further strengthening our leading market position by delivering development tools for ARM with an outstanding benchmark score of 5.04 CoreMark/MHz ”

- Stefan Skarin, IAR Systems

“ Our robust embedded software components are designed to be used in high performance applications targeted by Cortex-M7, including industrial control, safety and IoT ”

- Jean Labrosse, Micrium

“ ARM Cortex-M7 will bring substantially more computing power to embedded applications, and SEGGER will continue to innovate new products and features for each new generation of ARM processors ”

- Rolf Segger, SEGGER

Cortex-M7 Lead Partners

“The Cortex-M7 is well positioned between Atmel’s Cortex-M based MCUs and Cortex-A based MPUs enabling Atmel to offer an even greater range of processing solutions. Customers using the Cortex-M based MCU will be able to scale up performance and system functionality, while keeping the Cortex-M class ease-of-use and maximizing software reuse. We see the ARM Cortex-M7 addressing high-growth markets like IoT and wearables, as well as automotive and industrial applications that can leverage its performance and power efficiency” – Reza Kazerounian, Atmel

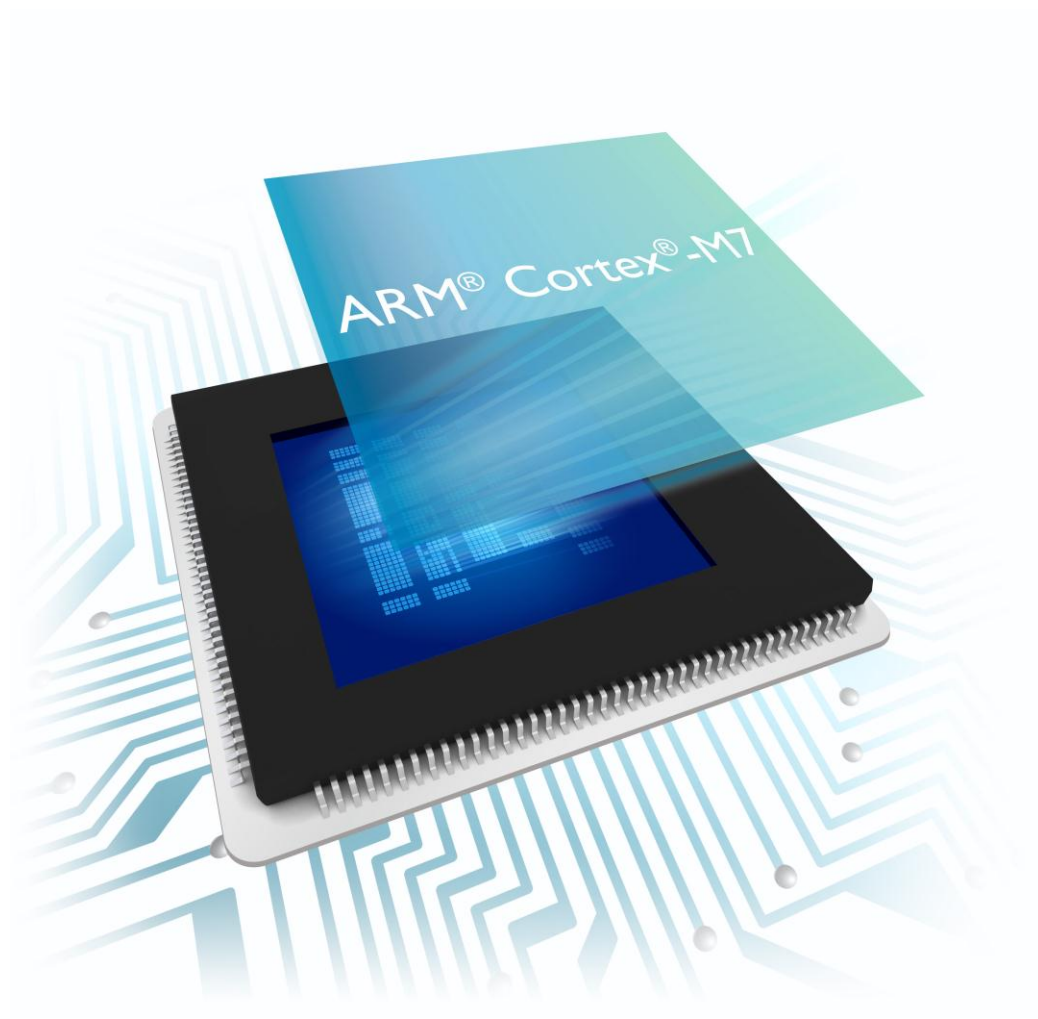


“Freescale Cortex-M7-based solutions dramatically extend MCU performance, opening new opportunities for our business. Our solutions will enable significant innovation and system-level efficiency in areas such as motor control, industrial automation and power conversion. These are rapidly growing markets where the high performance of the Cortex-M7 core eliminates the need for additional DSPs and microcontrollers” - Geoff Lees, Freescale



“Offering customers more intelligence and processing power on our STM32 microcontrollers is a major objective for ST, and the Cortex-M7 delivers that impressively. The Cortex-M7 core supports upwardly-scalable compatibility with our existing wide range of 500 Cortex-M STM32 microcontrollers, associated tools and software ecosystem, allowing developers to rapidly adopt our next-generation STM32 Cortex-M7-based MCUs” - Daniel Colonna, STMicroelectronics



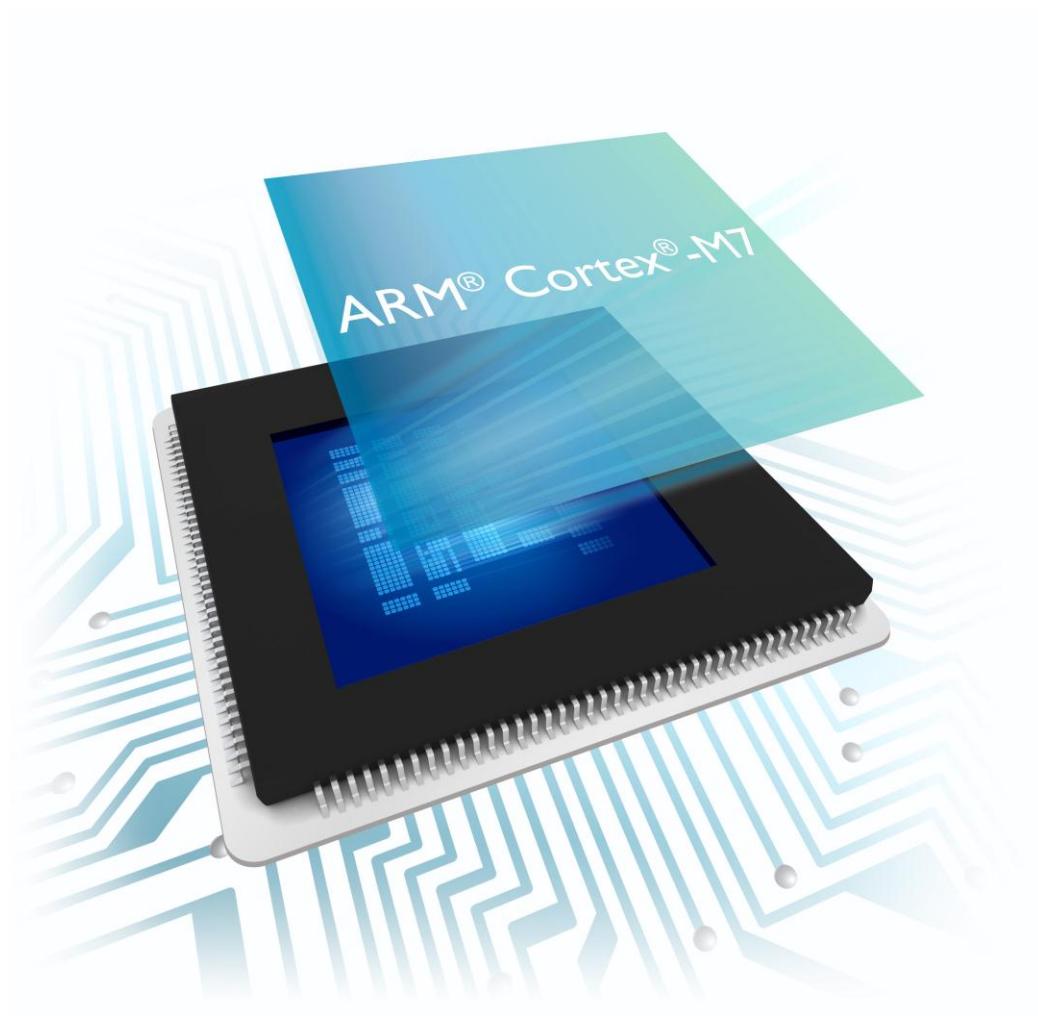


Supercharge Cortex-M based solutions

Develop versatile, scalable solutions

Address safety critical applications

Harness the broadest ecosystem



Thank You

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